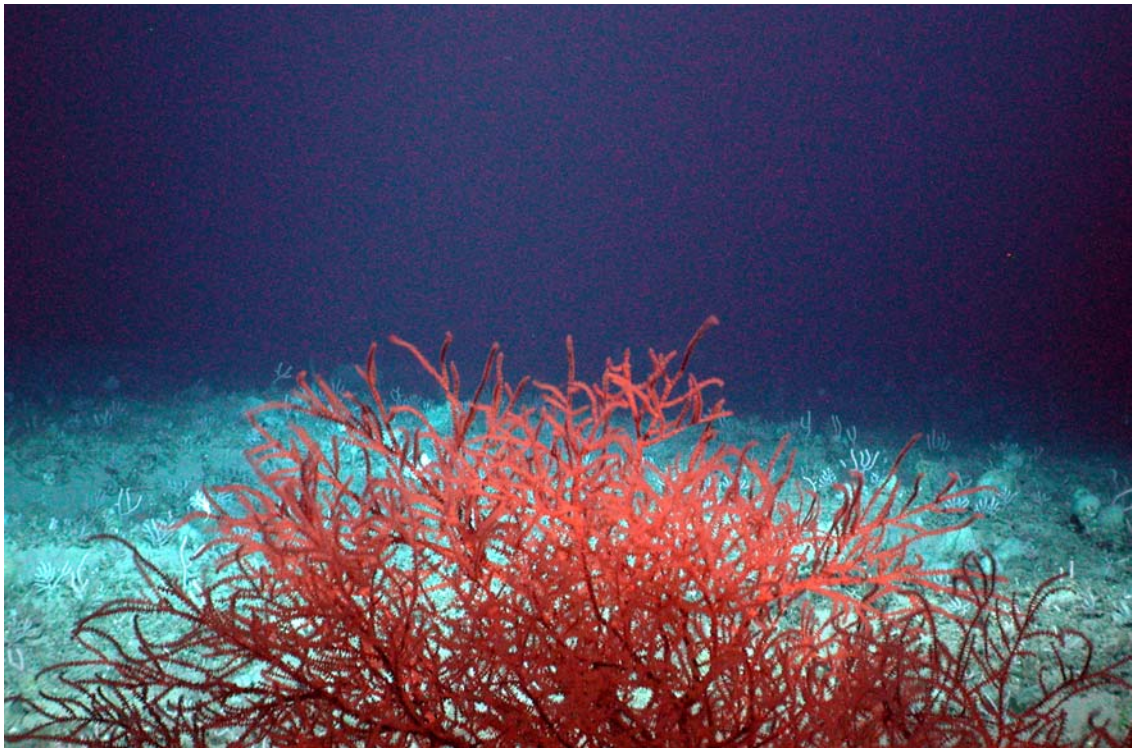
Summary: Deep-Sea Corals Workshop

International Planning and
Collaboration Workshop
For the Gulf of Mexico and
North Atlantic Ocean
Galway, Ireland
January 16-17, 2003



June 2003

Acknowledgments

This document summarizes the proceedings of the *Deep-Sea Corals Workshop* held in Galway, Ireland on January 16-17, 2003. The workshop was hosted by the Irish Marine Institute (MI) and organized by the U.S. National Oceanic and Atmospheric Administration (NOAA). This workshop builds on the growing collaboration between MI and NOAA under the Joint Statement of Understanding (JSU) signed by the two institutions in 1995. Efforts undertaken through the JSU include research on commercially important ground fish species, research to predict harmful algal bloom occurrences, oceanographic modeling, and the exchange of ideas and information on new technologies. This workshop represents how the JSU continues to evolve in response to emerging issues of joint concern.

NOAA and MI wish to thank all the individuals and organizations that participated in the two-day workshop. We hope the time and effort committed to this workshop will result in increased collaboration between countries and institutions with interests in understanding more about deep-sea coral ecosystems.

We would like to extend a special thank you to M. Bohan, S. Brown, R. Brock, A. Grehan, K. Heron, L. Oremland, M. O'Cinneide, A. Shepard, and G. O'Sullivan for their assistance in planning and executing the *Deep-Sea Corals Workshop* and for their insightful editorial comments on the *Deep-Sea Corals Summary Report*.

Deep-Sea Corals Workshop Participants

Summary:
Deep-Sea Corals Workshop

International Planning and Collaboration Workshop for the Gulf of Mexico and the North Atlantic Ocean

Prepared By

J.J. McDonough and K.A. Puglise

National Oceanic and Atmospheric Administration

NOAA Research – NOAA's Undersea Research Program
NOAA Research – Office of Ocean Exploration
NOAA Fisheries - Office of Science and Technology

In Cooperation with the Marine Institute, Ireland and Participating Institutions

June 2003

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Deep-Sea Corals Workshop

Connemara Coast Hotel
Galway, Ireland - January 16-17, 2003

EXECUTIVE SUMMARY

Overview – On January 16-17, 2003, a group of deep-sea coral researchers met in Galway, Ireland to discuss the need for an *International Deep-Sea Corals Action Plan*, identify critical information needs to increase our understanding of these unique and fragile habitats, and identify collaborative efforts to help meet those critical needs. Representatives from eight countries including Belgium, Canada, Germany, Ireland, Norway, Sweden, the United Kingdom, and the United States attended the workshop. Each of these countries has a vested interest in deep-sea coral research and management.

The workshop was hosted by the Irish Marine Institute and was organized by the U.S. National Oceanic and Atmospheric Administration, and represents the continuation of a collaborative partnership between the two institutions that began in 1995. Over the years, the partnership has provided an opportunity for joint activities focusing on a variety of environmental concerns including fisheries management, harmful algal events, oceanographic modelling, and seabed mapping through remote sensing. The issue of deep-sea corals is a recent addition to the growing body of work shared by Ireland and the United States.

Critical Information Needs –Participants identified critical information needs related to three categories: 1) locating and mapping deep-sea corals; 2) understanding more about coral biology and ecology; and 3) using specific deep-sea coral species as indicators of climate change. These needs, if met, would enhance our knowledge of the distribution and function of deep-sea coral habitats and the threats they face. The following outlines these information needs as identified by three breakout groups.

Mapping – This group identified two critical information needs for locating and characterizing deep-sea coral habitat, including a list of criteria for focusing mapping efforts. First, low-resolution maps (>10m pixel size) are required to identify broad areas that may contain deep-sea corals. These mapping efforts should focus on areas that are being considered for marine protective status, areas that are suspected to contain deep-sea coral habitat based on existing information, and deepwater areas that are being intensively used by the fishing and oil and gas industries. Priority areas are in:

- North America -- the southern West Florida Shelf in the Gulf of Mexico,

Workshop Accomplishments

- A joint "Statement of Need" for an *International Deep-Sea Corals Action Plan*
- Introduced the concept of developing a *State of the Deep-Sea Corals Report*
- Detailed descriptions of common themes for *Mapping*, *Biology and Ecology*, and *Paleoclimate Analysis*
- Detailed descriptions of critical information needs
- Detailed descriptions of collaborative projects for 2003 and beyond
- Discussed the process and model for developing an *International Deep-Sea Corals Action Plan*

suspected *Lophelia* banks off the northeastern coast of Florida and Georgia, the Grand Banks; and in

- Europe – Skaggerak, Sweden; and the French Canyon heads.

Second, high-resolution maps (<10m pixel size) are required to provide a baseline for characterizing areas of known deep-sea coral habitat. Priority areas are in:

- North America -- *Lophelia* banks off the coast of North Carolina, Stellwagen Bank off the coast of Massachusetts, the Northeast Passage; and in
- Europe -- Rockall Bank, Ireland and West Reef, Norway.

Biology and Ecology – This group identified three critical information needs that would improve our knowledge of the deep-sea corals themselves, the factors that influence their growth, reproduction, and distribution, and how communities of corals function as habitat for fish and invertebrates. First, the development of a comprehensive species inventory is required to establish a baseline for habitat characterization efforts. This will require collecting species from multiple locations and ensuring that taxonomic experts are available for species identification and classification.

Second, studies on growth and reproduction are required to better understand the life history of individual species, as well as the full effects of the threats they face. The group recommended that studies should focus on samples collected from a variety of locations and water depths, and selected some potential sampling areas including the northeast Gulf of Mexico, the Blake Plateau, the Gulf of Maine, the Porcupine Bight, and the Trondhjem Fjord in the Norwegian Sea.

Critical Information Needs

Mapping:

- Low-resolution over large areas
- High-resolution over small areas

Biology and Ecology:

- Species inventory and database
- Growth and reproduction studies
- Food web and species interaction studies

Paleoclimate Analysis:

- Hydrographic and oceanographic data
- Samples along the Gulf Stream
- Controlled growth experiments

Third, research on food web and species interactions is required to better understand how deep-sea corals function as habitat. There is a need to understand the role such habitat plays in terms of the life histories of individual species, as well as in support of biodiversity. The group recommended that these efforts build on current research, and include areas from the Gulf of Mexico to the Norwegian Sea to identify potential latitudinal differences in how species utilize deep-sea coral habitats.

Paleoclimate Analysis – This group identified three critical information needs that would allow researchers to better identify and understand past changes in climate (including triggers of climate change), and to develop more refined models for predicting future climate change. Deep-sea corals provide a unique record of temperature changes at a higher resolution than sediment cores (e.g. ± 1 year for deep-sea corals vs. ± 500 years for sediment cores). First, high-quality oceanographic data are required along the Gulf Stream and associated currents to better understand existing conditions as related to climate and corals.

Second, there is a need to collect coral samples for paleoclimate analysis from discrete areas along the Gulf Stream and associated currents to better understand the relationship between past oceanographic currents and the growth rates of corals. Specific sampling areas include the Blake Plateau, Orphan Knoll, the Northeast Channel, Rockall Trough, Lofoten Islands, Hatton Bank, Sedlo Seamount, Seine Seamount, and the Faroes-Shetlands Channel.

Third, there is a need to conduct controlled growth experiments to calibrate geochemical signals and relevant water mass properties. The species collected could come from any area. However, the experiments would require a high quality saltwater aquarium, laboratories capable of multiple dating techniques, and staff with advanced analytical skills.

Collaborative Projects – After identifying critical information needs, participants identified and described collaborative projects for the coming year and for the future that would help collect information for meeting these needs. Projects include existing, funded efforts, and "new ideas." Collaborative projects consist of short-term and long-term opportunities, such as available berth space on a funded research cruise or planning joint research expeditions. See the table below for an outline of some of the basic information generated on these projects:

Geography	# Projects	Timing	# Projects	Theme	# Projects
United States	5	2003	10	Mapping	11
Canada	1	Multiyear	11	Biology/Ecology	16
Europe	14	Future	10	Paleoclimate	3
Canada/Europe	1			Multidisciplinary	1
United States/Europe	6				
All Regions	4				

Geographic coverage, timing, and theme of potential collaborative projects.

A Proposed International Transatlantic Expedition – Participants identified objectives for a potential International Transatlantic Expedition to explore and research deep-sea coral habitats in relation to the Gulf Stream and associated currents. The expedition could occur in 2005, and would consist of integrated, multidisciplinary cruises using common protocols and procedures for collecting and analyzing information. Emphasis would be given to meeting the critical needs identified by this workshop

Transatlantic Expedition Objectives

Research:

- Locate & map deep-sea coral habitat
- Assess biodiversity & species abundance
- Describe changes in species & communities with changes in latitude and depth
- Assess recruitment processes
- Correlate fish stock assessments with paleo-record of coral habitat condition
- Collect coral specimens for paleoclimate analysis

Education & Outreach:

- Provide real-time links to classrooms
- Develop expedition-specific lesson plans
- Organized media and web coverage

I. Introduction

On January 16-17, 2003, a group of deep-sea coral researchers met in Galway, Ireland to discuss the need for an *International Deep-Sea Corals Action Plan*, identify critical information needs to increase our understanding of these unique and fragile habitats, and identify collaborative efforts to help meet these critical needs (See Appendix A for the workshop agenda). Representatives from eight countries including Belgium, Canada, Germany, Ireland, Norway, Sweden, the United Kingdom, and the United States attended the workshop (See Appendix D for a list of participants). Each of these countries has an interest in deep-sea coral research and management.

The *Deep-Sea Corals Workshop* was a direct result of an existing collaboration between the U.S. National Oceanic and Atmospheric Administration (NOAA) and the Irish Marine Institute (MI) who have recognized that these slow growing corals provide essential habitat for fish and invertebrates, may act as sources of biodiversity, provide novel bio-compounds for use in the biotechnology industries, and serve as climate change indicators. This workshop was an outgrowth of the *Deep-Sea Corals Collaboration Planning Meeting* held in Tampa, Florida on November 14, 2002, in which the objectives were to: (1) identify common themes of research among deep-sea coral researchers; (2) become acquainted with the international community of deep-sea coral researchers; (3) discuss potential areas of collaboration; and (4) make plans for a follow-up meeting. The *Deep-Sea Corals Workshop* was held to further assess the critical needs associated with the common themes and to identify areas of future collaboration.

Significant progress was made during the two-day workshop, and participants were able to identify some of the most critical needs related to: locating and mapping deep-sea corals; understanding more about coral biology and ecology; and using specific deep-sea coral species as indicators of climate change. Progress was also made in identifying future projects and field operations that can help meet these information needs. Real time products and outcomes achieved during the workshop include:

1. A joint "Statement of Need" for an *International Deep-Sea Corals Action Plan;*
2. Introduced the concept of developing a *State of the Deep-Sea Corals Report;*
3. Detailed descriptions of common themes for *Mapping*, *Biology and Ecology*, and *Paleoclimate Analysis* of deep-sea corals;
4. Detailed descriptions of collaborative projects for 2003 and beyond*;* and
5. Discussed the process and model for developing an *International Deep-Sea Corals Action Plan.*

The information collected at the workshop will help lay the foundation for collective and collaborative action. However, much work remains to be done. The following is a detailed report that summarizes the hard work of the workshop participants and provides recommendations for "next steps."

II. Background

In comparison to their tropical counterparts, the state of knowledge on cold, deep-sea corals is minimal. Scientists still know little about deep-sea coral distribution, biology, and their function as essential fish and invertebrate habitat. Recently, interest has been building among the scientific community and the public to determine the role of these "forests beneath the sea" and their relation to commercial fisheries.

Deep-sea corals consist of both scleractinians (stony corals) and gorgonians (soft branching corals) and are found in the dark, cold oceanic waters worldwide. They are fragile, long-lived, and slow growing, thus making them extremely vulnerable to physical disturbance.

Human activities pose the most significant threat to deep-sea corals. Slow growing coral species may live for centuries, yet be destroyed in seconds by human activities such as trawling, dredging, and natural resource exploration. Destructive fishing practices have been shown to remove coral forests, and leave rubble behind which has far less value as essential fish habitat.

Although deep-sea corals are found in all of the world's oceans, the workshop focused on the deep-sea corals along the Gulf Stream current, which begins in the Gulf of Mexico and ends in the Northern Atlantic Ocean (Figure 1). The workshop focal point was on the deep-sea corals of the Atlantic Ocean, not because they are more important, but because this workshop developed out of a burgeoning relationship between NOAA and MI. The hope is that lessons learned from concentrating on the Atlantic Ocean can be applied to other locations where deep-sea corals are found.

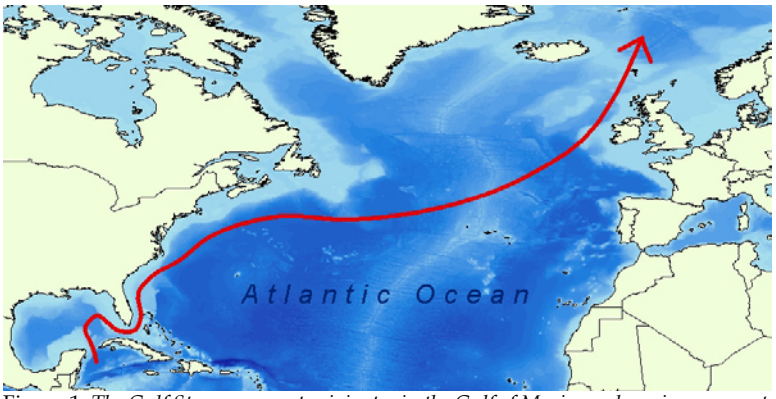

Figure 1: *The Gulf Stream current originates in the Gulf of Mexico and carries a current of warmer water through the North Atlantic Ocean, where it terminates.*

One of the outcomes of the workshop was a "Statement of Need" that was collectively penned by the researchers attending the *Deep-Sea Corals Workshop*. In the Statement of Need, workshop attendees declared the importance of deep-sea corals, the potential threats to their existence, the need to increase public awareness about deep-sea corals, and to engage with industry and resource managers to develop strategies for sustainable management of the corals.

Statement of Need:
Cold-water corals are widely distributed in the North Atlantic Ocean

A workshop was held on January 16-17, 2003 in Galway, Ireland as part of an on-going collaboration between the U.S. National Oceanic and Atmospheric Administration (NOAA) and the Irish Marine Institute (MI), to bring together leading cold-water coral experts from the United States, Canada, Norway, Sweden, Germany, Belgium, the United Kingdom and Ireland, to begin formulating an *International Deep-Sea Coral Action Plan*.

Spectacular underwater video and photographs of deep, cold-water corals in Norway and off the west coast of Ireland have revealed a fascinating world of coral gardens, reefs, and giant carbonate mounds which support an amazing array of marine life. These are distinct from shallow tropical corals as they occur in dark frigid oceanic waters (> 100 meters) often beyond the continental shelf break and fjord waters. Now countries all around the Atlantic are beginning to explore the distribution of these important ecosystems that appear to be connected by common ocean margin characteristics and the uniting influence of the Gulf Stream.

Pioneering studies have shown that cold-water corals are outstanding examples of marine natural heritage, essential habitats for fish, as major biodiversity hot-spots in the deep-sea, as potential sources of novel bio-compounds of use in the pharmaceutical and biotechnology industries, and in medicine, and as climate change indicators.

Cold-water corals are long-lived, slow-growing, fragile, and vulnerable to physical disturbance. The rapid expansion in deep-sea fishing and oil and gas exploration now threatens the very survival of these complex habitats. Scientists have documented widespread damage to corals off Canada, the United States, and Norway resulting from the destructive effects of using trawling equipment.

International scientists participated in the Galway meeting due to a shared responsibility and mounting concerns over the rapid loss of cold water-coral habitats (many of which have existed for 1000s of years). A process has begun to identify and prioritize the research required to unlock the secrets of these ecosystems and to underpin international conservation initiatives required to ensure the long-term viability of these ecosystems. A concerted effort is also being undertaken to increase public awareness of the plight of deep, cold-water corals and to engage with industry and resource managers to develop strategies for sustainable management of the corals.

The problems facing coral ecosystems are similar in every country so the Action Plan under development will identify opportunities to pool resources, share expertise, and exchange data to rapidly increase our scientific understanding of the ecosystem, which will form the basis for advice to policy makers and resource managers on both sides of the Atlantic.

III. Developing an International Deep-Sea Corals Action Plan

An *International Deep-Sea Corals Action Plan* will provide a blueprint for:

- Exploration – locating habitat
- Mapping – characterizing habitat
- Research – assessment and understanding
- Public Awareness – education and stewardship
- Management

While deep-sea coral habitats exist within the exclusive economic zones (EEZs) and other political boundaries of several nations, many can be found in areas outside of national jurisdictions. Given the fragile nature of these corals and their ecological importance, an *International Deep-Sea Corals Action Plan* would provide a blueprint for participating countries to collaborate on exploration, mapping, research, public awareness, and management of deep-sea corals in international waters. Such an international action plan would also guide efforts to manage human activities that have a negative effect on deep-sea coral habitats in international waters; enable member nations to address similar issues and problems in a systematic manner; establish consistency in scientific methodology and data collection; improve information exchange; and enable participating nations to pool resources to address critical needs. An *International Deep-Sea Corals Action Plan* may also provide grounds to establish an international deep-sea corals "Marine Protected Area" (MPA) on the high seas – a concept that was discussed a number of times during the workshop as a potential long-term target.

An *International Deep-Sea Corals Action Plan* will not replace or duplicate existing collaborative efforts in specific regions. In contrast, it may provide additional incentive and support for efforts that are currently struggling due to a lack of funding and other resources.

Current State of Regional Efforts

Europe – Currently, much of the international environmental work in Europe is being conducted under the "*Sixth European Union Framework Programme*" (EU FP6). Specific activities under EU FP6 related to deep-sea corals are guided by the "*Atlantic Coral Ecosystem Study*" (ACES), which coordinates research, management, and legislative activities related to deep-sea coral habitat that are conducted by member countries. Significant progress on locating, mapping, and characterizing deep-sea coral habitat has been made easier under the EU ACES Project and by the Irish National Seabed Survey, which has mapped the Irish EEZ equivalent from 200 m out to 4000 m.

Canada – Dalhousie University in Halifax, Nova Scotia is currently developing a proposal to establish a *Deep-Sea Coral Research Network* to guide research and management efforts related to deep-sea coral habitat. The proposal addresses four major topics: 1) high-resolution paleoclimate studies using deep-sea corals as a proxy for temperature changes; 2) chemical and biological studies of deep-sea corals; 3) the ecology of deep-sea coral habitats and the effects of fishing; and 4) education and public outreach. While the emphasis is on locating and understanding more about deep-sea coral habitats in Canadian waters, the intention of the network is to formalize collaborations with scientists in Europe and the United States. The Canadian workshop participant has indicated that the proposal was well received, and anticipates funding to support approximately five years of activity.

United States – Deep-sea coral exploration, research, and management in U.S. waters are scattered among numerous agencies and institutions, and has trouble competing with shallow, temperate and tropical coral reef priorities. Efforts to locate and characterize deep-sea coral habitats within NOAA are funded through three NOAA line offices: NOAA Fisheries, NOAA Research [through the Office of Ocean Exploration (OE) and NOAA's Undersea Research Program (NURP)], and NOAA's Ocean and Coasts. Other federal

and state agencies (including the U.S. Geological Survey and Minerals Management Service), as well as public and private institutions also conduct deep-sea coral work. An *International Deep-Sea Corals Action Plan* could provide an incentive for improving the coordination of U.S. efforts.

A Proposed Framework

During the workshop, participants reviewed a potential framework (Figure 2) for developing, implementing, and evaluating the effectiveness of an *International Deep-Sea Corals Action Plan* that would require the participation and interaction of scientists, natural resource managers, and educators. The framework outlines a phased approach that would allow participants to develop, assess, and prioritize specific actions (strategies) based on the best available information on deep-sea coral distribution, health, and perceived threats. The framework also includes an evaluation phase that would be conducted once actions are being implemented, which would allow participants to modify their actions based on whether or not they were effective.

The proposed framework also provides a description of specific actions that could be undertaken to develop the *International Deep-Sea Corals Action Plan*, as well as some methods that could be used to organize participants. Specifically, it was recognized that if such an action plan is to be constructed, it would require the establishment of: 1) working groups made up of representatives from each participating nation that would be responsible for implementing each phase and developing interim products; 2) an advisory group (or groups) that would review products and progress; and 3) formal mechanisms for making decisions and approving actions.

Upon reviewing and discussing the proposed framework, participants recognized the need to look within their individual institutions and organizations to generate formal support. It was also recognized that particular efforts such as assembling and organizing existing information on deep-sea corals, developing interim products such as a *State of the Deep-Sea Corals Report*, and conducting collaborative field work during the upcoming field season (2003) need not wait for a formal *International Deep-Sea Corals Action Plan*. In fact, many of these efforts could be conducted under existing institutional arrangements, and the results could be used to further the development of an *International Deep-Sea Corals Action Plan*.

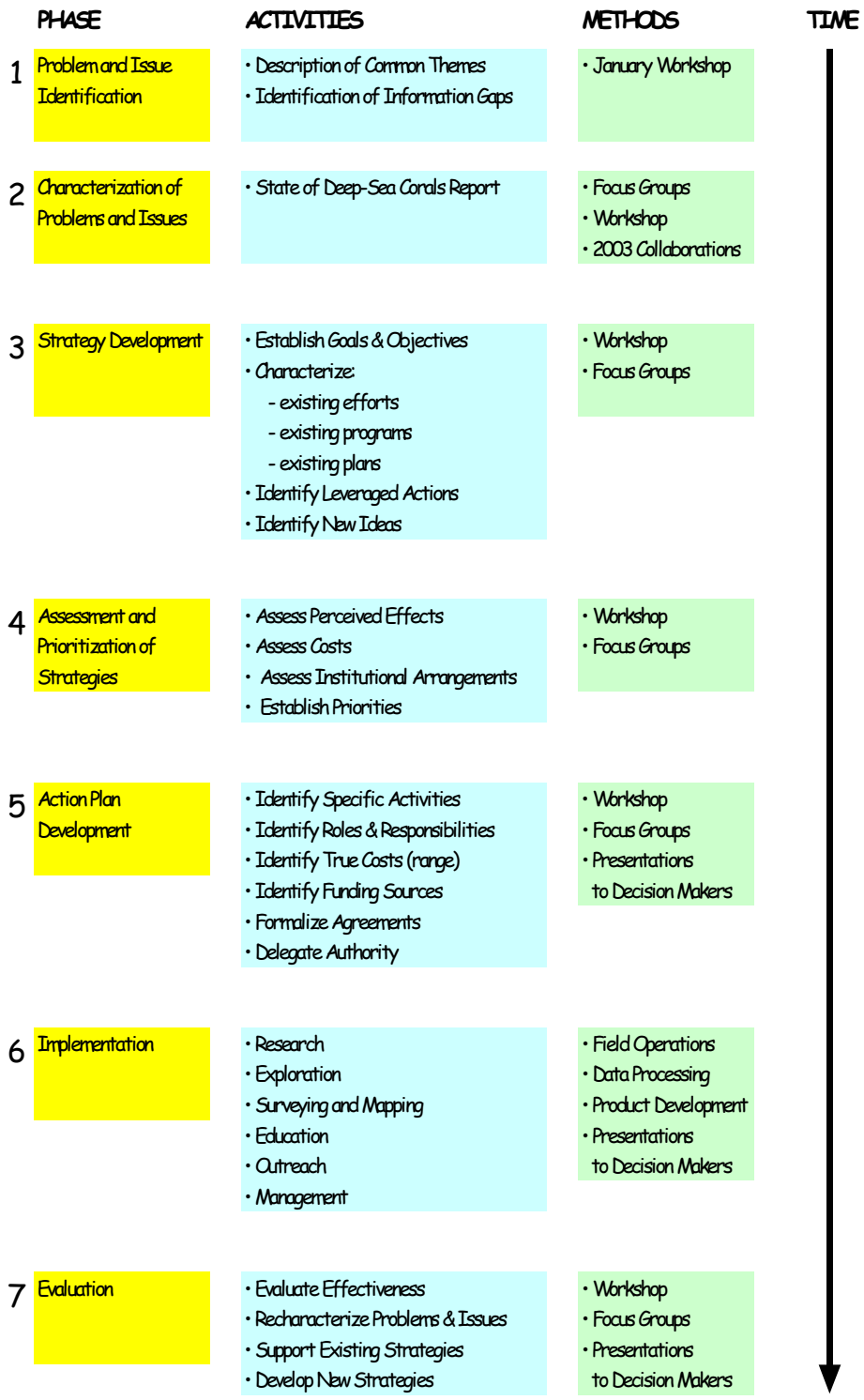

Figure 2. *Proposed framework to develop, implement, and evaluate the effectiveness of an International Deep-Sea Corals Action Plan.*

IV. Developing a *State of the Deep-Sea Corals Report*

The location, distribution, status, and health of deep-sea coral habitats are poorly understood. Even for those areas where reefs have been well mapped and filmed, little is known about how the species function together as a community, and as habitat for fish and invertebrates. In addition to the challenges that scientists face in accessing these areas, even less is known about how these habitats may change over time. Therefore, as an initial step toward developing an *International Deep-Sea Corals Action Plan*, participants at the workshop discussed preparing a *State of the Deep-Sea Corals Report*. Participants agreed that such a report could help organize existing knowledge on these habitats, the perceived threats that they currently face, and elucidate critical information required for making informed management decisions.

As with the discussion of an *International Deep-Sea Corals Action Plan*, participants debated the potential contents and scope of the report, and agreed that it would be worthwhile to prepare a well-organized, streamlined report, a document that would provide users with a quick overview of the most salient information available. Participants also recognized that the work conducted at the workshop on further describing the common themes related to deep-sea corals – locating and mapping habitat, conducting research on biology and ecology, and assessing deep-sea coral species as indicators of climate change – represents an initial effort toward developing the report. However, no agreement was reached on an outline, or on how to proceed in preparing the report.

Given this situation, the following outline is presented by NOAA as a potential method for developing a *State of the Deep-Sea Corals Report*:

I. Executive Summary
II. Introduction – background, purpose, overview of document
III. Regional Overview: (these are offered as examples based on discussions)
IV.

- Pacific Northwest
- Hawaii & the Western Pacific
- Gulf of Mexico
- Caribbean
- Southeastern US
- Northeastern US
- Eastern Canada
- Western Ireland
- Scandinavia
- North Sea
- Bay of Biscay
- Western Spain and Portugal

Each Overview would contain:

- Abstract
- Location of known and suspected habitat (maps)
- Status (health and perceived threats)
- Level and type of research conducted
- Upcoming efforts and opportunities

V. Framework for Future Actions – application to the *International Deep-Sea Corals Action Plan*
VI. Appendices – maps, tables, etc.

V. Common Themes

Overview:

Prior to the *Deep-Sea Coral Collaborative Planning Meeting* held in Tampa, Florida on November 14, 2002, deep-sea coral research profiles were requested from anticipated meeting participants. Preliminary common themes were identified based on these profiles, including: 1) mapping the distribution of deep-sea corals; 2) ecology of organisms associated with deep-sea corals; 3) physiology of deep-sea corals – indicators and response to change; 4) taxonomic studies; and 5) paleo-retrospective analyses. Common themes were developed as focal points for future discussion regarding the status of deep-sea corals research.

For the workshop, the original five common themes were condensed into three themes: (1) *Mapping*; (2) *Biology and Ecology* (including the former common themes of ecology, physiology, and taxonomy as subtopics); and (3) *Paleoclimate Analysis*. Additionally, participants had the opportunity to edit, rewrite as appropriate, and come to consensus regarding the common themes and overview statements at the workshop (see Appendix B for full descriptions of the overview statements).

Information Needs:

Working in three groups, participants were tasked with identifying and prioritizing critical information needs within each theme. Participants identified 26 distinct information needs – *Mapping* (7), *Biology and Ecology* (17), *Paleoclimate Analysis* (5) – some as specific as gathering data on the impacts of new optical scanning technologies, to others such as data from hydrographic surveys that would provide a foundation for future research and management efforts. Of these, 8 were identified as "critical" and requiring immediate attention– *Mapping* (2), *Biology and Ecology* (3), *Paleoclimate Analysis* (3). Table 1 lists the information needs identified by each group.

Table 1. *Information needs identified by the participants.*

Group 1 - Mapping	Group 2 - Biology and Ecology	Group 3 - Paleoclimate Analysis
* Low-resolution large-scale surveys	Information on how *Lophelia* functions as habitat	Low-resolution large-scale surveys
* High-resolution site-specific surveys	Data on deep-sea corals faunal associations	High-resolution site-specific surveys
Monitoring data	Colonization and dispersal data	* Specimens
Specimens	Data on larval biology	* Time-series data of hydrographic changes
Optical survey impact data	Data on reproductive ecology	* Controlled growth experiments
Spatial information on research gaps	* Data on coral growth rates and limiters	
Development of acoustic survey methods	Data on symbiotic relationships	
	Molecular markers for recruitment studies	
	Reef succession	
	Recolonization of disturbed areas	
	Habitat preferences	
	* Data on food web - trophodynamics	
	Biodiversity data and estimates	
	Thermal physiology	
	Species identification and descriptions	
	Monitoring data	
	* Development of taxonomic tools and expertise	

** = "Critical Information Needs" addressed in detail by workshop participants.*

The information needs identified by the participants can be classified under seven categories that represent a means for designing multidisciplinary efforts that could be applied to locating deep-sea coral habitats, developing a base-level characterization, and learning more about their function and health.

1. *Mapping* – Using multibeam and other technologies, develop low-resolution maps covering large areas for identifying potential locations of deep-sea corals, and develop high-resolution maps for site-specific areas where deep-sea corals are known to exist. Use video, still cameras, and voucher specimens to ground-truth the bathymetric data and to develop habitat characterization maps.

2. *Oceanographic Data*– Collect high quality oceanographic data in order to enhance knowledge of the physical parameters that effect the distribution and extent of deep-sea coral habitats.

3. *Geology and Geomorphology* – Collect data on the underlying geology of deep-sea corals, as well as data on their morphology. This information is required to enhance understanding of colonization, reef succession, recolonization after a physical disturbance, and for better understanding habitat preferences for select species.

4. *Biology and Physiology* – Collect and analyze specimens in order to better identify and understand distinct coral species, to better characterize symbiotic relationships, and to understand more about their life history.

5. *Ecology* – Collect data on associated species interactions with deep-sea coral habitats. This information is critical for determining the utility of deep-sea coral habitats in terms of function.

6. *Human Activities* – Collect data on human activities that are perceived to play a role in the physical destruction of deep-sea coral habitats, as well as activities that may have a detrimental effect on their health. This data is required to better understand how human activities affect deep-sea coral habitats.

7. *Time-Series Data* – Collect standard data sets over long periods of time to help identify changes in habitat over time.

Critical Information Needs:

For the purposes of this workshop, Critical Information Needs (identified by an asterisk in Table 1) were defined as those that the participants should spend more time characterizing and understanding. Specifically, participants were asked to characterize each Critical Information Need in terms of:

Geography – Where do we need to focus our efforts?
Technology – What types of technology are required to meet the need?
Timing and Duration – When should information be collected and how often?
Users – Who needs the information?
Critical Contributors – What institutions are critical to meeting this information need?

Appendix B provides a detailed overview of the work accomplished on the Critical Information Needs, while Tables 2 and 3 list each Critical Information Need and summarize the suggested target areas and required technologies:

Table 2. *Target areas for focusing efforts to meet Critical Information Needs. Geographic regions are identified where participants would like to obtain maps, samples, and conduct research. To meet some of these information needs, it is necessary to collect data on a broad scale across all regions. For example, collecting specimens from multiple areas is required for paleoclimate analysis.*

	Geographic Regions										
	North America					Europe					
Critical Information Needs	**West Florida Shelf**	**Gulf of Mexico**	**South Atlantic Bight**	**Blake Plateau**	**NE US and Eastern Canada**	**Ireland**	**Norwegian Sea**	**Sweden Fjords**	**Bay of Biscay Slope**	**Iberian Penninsula**	**All Regions**
Group 1 - Mapping											
Low-resolution large-scale surveys	x		x		x			x	x		
High-resolution site-specific surveys					x	x	x	x			
Group 2 - Biology and Ecology											
Data on coral growth and reproduction		x			x	x	x	x	x	x	
Data on food web and species interactions											x
Development of taxonomic tools and a species inventory											x
Group 3 - Paleoclimate Analysis											
Specimens				x	x	x	x	x			
Time-series data of hydrographic changes											x
Controlled growth experiments											x

Table 3. *Technologies required for collecting Critical Information Needs*.

	Technology Requirements													
Critical Information Needs	**Multibeam**	**Side-Scan Sonar**	**Laser Line Scan**	**Coral Reef Identification Algorithms**	**Seismic Profilers**	**Bottom Samplers**	**Bottom, Mid-water, and Surface Trawls**	**Subs, ROVs, and AUVs**	**Benthic Landers**	**High Quality Video and Still Cameras**	**Standrad Oceanographic and Water Chemistry**	**Biological Assessment Instruments**	**Lab Facilities and Aquaria**	**Models**
Group 1 - Mapping														
Low-resolution large-scale surveys	x			x										
High-resolution site-specific surveys	x	x	x	x	x	x		x		x	x			
Group 2 - Biology and Ecology														
Data on coral growth and reproduction						x		x		x	x		x	
Data on food web and species interactions						x	x	x	x	x			x	
Development of taxonomic tools and species inventory						x		x				x	x	
Group 3 - Paleoclimate Analysis														
Specimens						x		x		x	x	x	x	x
Time-series data of hydrographic changes													x	
Controlled growth experiments												x	x	x

VI. Collaborative Projects

One of the primary objectives of the workshop was to identify opportunities for scientists to collaborate on field operations and other efforts related to deep-sea corals and associated species. This objective was a continuation of a preliminary list of potential collaborative projects drawn up at the *Deep-Sea Corals Collaboration Planning Meeting* in Tampa, Florida on November 14, 2002. Given further development of the common themes and the identification of Critical Information Needs within those themes, participants developed a more comprehensive list of collaborative projects that 1) identified existing efforts funded for the upcoming year that provide an opportunity for collaboration; and 2) identified and described future projects with potential for collaboration.

During their discussions, participants identified several types of collaborative efforts (Table 4), which, if undertaken, would provide a solid foundation for continued collaboration and coordination related to exploration, research, education, and management, including data management, technology development, and resource management.

Table 4. *Examples of the types of collaborative opportunities.*

Project Type	Description
Exploration	Mapping and discovery expeditions; development of exploration "targets"; collaborative product development based on results
Research	Research expeditions; international science teams; development of a shared specimen archive; lab work
Education and Outreach	Curriculum development; development of interpretive exhibits and displays; use of international media outlets
Data Management	Systematic development and use of metadata to ensure data consistency and sharing; development of a GIS-based Atlantic Atlas
Technology Development	Development and use of advanced underwater vehicles (AUVs) and sensors; development and use of remote sensing and acoustic instruments
Resource Management	Development of management zones on the high-seas; sharing of techniques and strategies for management and restoration

Appendix C provides an overview and summary of the proposed projects, including a description of each project and its key activities, as well as an accounting of the themes that are addressed and the areas that will be targeted. Of the 31 projects described by participants, 14 are scheduled to occur during 2003 (5-mapping, 7-biology/ecology, 2-multidisciplinary). In addition, there is a distinct emphasis on conducting work in European waters.

Mapping – Participants identified 11 mapping related projects, 5 of which are occurring in 2003. Each project is similar in the application of multibeam technology; ground-truthing the data using remotely operated vehicles (ROVs) or manned submersible video and still cameras, and the collection of sediment and biological samples for analysis. Geographically, there is an emphasis on projects in European waters, with several of the projects proposing to visit more than one area.

Biology and Ecology – Participants identified 16 projects focusing on biology, ecology, and taxonomy. Seven of these projects are scheduled for 2003. As with mapping, these projects share similarities in their approach, including: using the best available hydrographic information to identify target areas for study; using a variety of sampling and observation techniques (including ROVs and manned submersibles) to collect specimens of live coral, coral rubble, and associated species; and laboratory analysis. Geographically, there is an emphasis on conducting work in European waters, as well as in the Gulf of

Mexico. These projects indicate a growing need and opportunity for establishing consistent methods for addressing similar scientific questions, as well as opportunities for establishing a database and sample archive that would be accessible by all concerned countries and institutions.

Paleoclimate Analysis – Only one project was described for this theme, and would require the collection of voucher specimens of specific species along the Gulf Stream and associated currents. Participants recommended that this be one of the major objectives of the proposed International Transatlantic Expedition described in the next section.

Multidisciplinary – Four projects developed by the participants can be described as multidisciplinary, using a comprehensive, multiyear approach to map and characterize deep-sea coral habitat, conduct research, and in one case, to establish long-term monitoring.

See Appendix C for individual project descriptions.

VII. A Proposed International Transatlantic Expedition

Participants discussed and described an International Transatlantic Expedition to explore deep-sea coral habitats in relation to the Gulf Stream and associated currents. The participants also identified specific objectives for the expedition. Most importantly, participants recognized that to be successful, these objectives must be simple, straightforward, and very clear. The concept of using this expedition to promote other site-specific missions related to deep-sea corals was also discussed, and it was agreed that this was a viable approach. Furthermore, participants discussed establishing consistent methods in terms of data collection and summary product development, and the group agreed that this would be critical not only for the expedition, but for meeting the requirements of an *International Deep-Sea Corals Action Plan*.

The International Transatlantic Expedition – An Overview

The Concept – The Transatlantic Expedition to explore and research deep-sea coral habitats of the Gulf Stream would be an integrated exploration and research program with broad public appeal that represents an effective, efficient, and innovative way to better understand and manage underwater resources. The International Transatlantic Expedition would consist of integrated, multi-disciplinary cruises, using common protocols and multiple partners at targeted sites to support science-based discovery and characterization. By using the expeditionary approach, expedition participants could address the realities and expectations of today's funding environment — "do more with less" and "capture the public's attention."

The Objectives – The International Transatlantic Expedition would provide an opportunity for participants to address a suite of complementary objectives related to (1) exploration and research, (2) education, (3) outreach and communications, (4) data management and mapping, and (5) the development of products that emphasize accomplishments. The objectives discussed at the workshop include:

- **Exploration and Research** – explore dynamics and inter-dependencies of deep-sea coral habitat and biological communities through a multi-disciplinary approach using in situ underwater systems, pioneering acoustic and observational technologies, and traditional sampling methods.

  Over-arching research objectives were cited at the workshop as appropriate to critical science and management needs in all regions of the expedition, including:

  Ecology of deep-sea coral ecosystems:
  - Locate, map, and describe the types of deep-sea coral reefs, including dominant species and reef geomorphologies;
  - Assess effects of deep-sea corals on associated species biodiversity and abundance;
  - Describe biogeographical changes in deep-sea coral reef communities from the subtropics to boreal latitudes and from shallow to deep water; and
  - Determine changes in deep-sea coral reef communities with the type, size, and isolation of reef formation.

  Physiology of deep-sea corals:
  - Determine changes in deep-sea coral metabolism, thermal tolerance, morphology, and genetics by depth and geographic area; and

- Describe recruitment processes in deep-sea coral populations and transport vectors for pre-settlement juveniles—Are transatlantic deep-sea coral populations linked by the Gulf Stream and associated currents?

Paleoceanography:

- Model and predict future environmental changes (e.g., shifts in major water masses) using retrospective analyses of past environmental conditions as recorded in fossil and living coral skeletons; and
- Correlate fish stock assessments with paleo-record of conditions/changes in corals.

- **Education** – immerse students, teachers, and marine educators through at-sea participation, links to shore-based classrooms, and expedition-based curricula.

- **Outreach** – report stories of discovery, science, and management challenges through traditional (e.g., TV, newspapers, open houses) and multimedia (e.g., web sites, live satellite uplinks) outlets; develop an International Transatlantic Expedition Web Site that reports daily discoveries and findings through text, imagery, and sounds (e.g., expeditions at http://oceanexplorer.noaa.gov).

- **Data Management and Mapping** – catalog and summarize all expedition discoveries, activities, data, samples, video tapes, and photos; overlay high-resolution bathymetry (e.g., side-scan, multibeam) with submersible tracks, habitat features and biological communities, as well as real-time on board mapping for areas where little or no high-resolution bathymetry exists.

- **Application of Results** – develop mix of products for different target audiences, both real-time (during the expeditions), short-term (immediately after the expeditions), and over the long-term; focus on products that have a direct application to improving management of ocean resources.

Preparing for an International Transatlantic Expedition: A Proposed Method

Preparing for a Transatlantic Expedition that could involve several ships, submersibles, ROVs, AUVs, and other equipment will require a great amount of planning and preliminary work. Although not discussed at the workshop, the following outline is offered by NOAA as a potential method for organizing the expedition:

- Assess existing data and research results from 2003 to determine knowledge gaps
- Assess knowledge gaps as they relate to the objectives identified at the workshop
- Refine objectives as necessary
- Identify partners, potential funding sources, and integrate partners into subsequent planning process
- Develop projects for 2004 that relate to refined objectives:
  - Identify targets
  - Develop consistent methodologies
  - Develop a centralized database for organizing results
- Develop products based on results to:
  - Further refine objectives
  - Identify participants
  - Attract investors

- Conduct International Transatlantic Expedition planning:
  - Develop expedition-specific objectives
  - Define activities and methodologies:
    - Exploration and mapping
    - Research
    - Education
    - Outreach
  - Identify science parties
  - Identify vessels and equipment requirements
  - Develop a schedule
- Identify other field operations (site-specific) that complement the International Transatlantic Expedition
- Develop product oriented connections with these operations

VIII. Potential Actions and Next Steps

The participants recognized that developing an integrated approach to locate, study, and manage deep-sea corals requires the support of the relevant governments, the science community, natural resource managers, industry, and the general public. Therefore, they identified events where the approaches described in this report could be communicated and discussed. They also identified existing products that describe deep-sea corals and the threats they face, as well as aquaria and displays that convey similar messages (Tables 5 - 7).

Table 5. *Upcoming events where presentations on deep-sea corals may prove useful for establishing formal collaborations.*

Year	Month	Activity	Location
2003	March	U.S. Congress - House Ocean Caucus Luncheon	US: Washington, D.C.
2003	April	Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB)	Tazmania
2003	April	EGS-AGU-EUG Joint Assembly	France: Nice
2003	Spring	Fisheries Exhibition	Scotland: Glasgow
2003	June	UN Meeting: Law of the Sea	US: New York
2003	June	Workshop on the Governance of High Seas Biodiversity Conservation	Australia: Cairns
2003	July	7th International Conference on Colenterate Biology	US: Lawrence, Kansas
2003	August	American Fisheries Society (MPA Component)	Canada: Quebec
2003	August	Deep-Sea Biology Symposium	US: Oregon
2003	September	Second International Symposium on Deep-Sea Corals	Germany: Erlangen
2003	September	Ocean Margins Research Conference	France: Paris
2003	November	Geological Survey of Ireland Seminar	Ireland: Dublin
2003	September	International Council for the Exploration of the Seas	Estonia
2003	December	New Zealand Deep-Sea Fisheries	Queenstown, New Zealand
2004	June	10th International Coral Reef Symposium	Japan: Okinawa
2004	Unknown	EurOcean: marine science and ocean technology	Ireland: Galway
2004	Unknown	GEOHAB	Ireland: Galway
2005	Unknown	International Society for Reef Studies Regional Meetings	Unknown
Unknown	Unknown	Irish Coral Task Force	Unknown

Note: The House Oceans Caucus Luncheon was conducted on March 14th, 2003.

Table 6. *Products that describe deep-sea corals and the threats they face.*

Title or Description	Product Type	Country of Origin
National Geographic special on Ireland's deep-sea corals	Video	Ireland and Germany
"Out in Nature" - The effects of trawling on deep-sea corals	Video	Norway
Geological Survey of Ireland - seabed survey	Book and Maps	Ireland
"Deep Water Corals and Process in the Seafloor"	Book	Norway
"Proceedings of the 1st International Symposium on Deep-Sea Corals"	Book	Canada

Table 7. *A few examples of aquaria and exhibits that highlight deep-sea corals*.

Title or Description	Country
Smithsonian Marine Station	United States
Florida Aquarium	United States
Monterey Bay Aquarium	United States
Mystic Aquarium and Institute for Exploration	United States
National Museum of Canada	Canada
Scottish Deep-Sea Experience	United Kingdom

The following is a list of potential actions that could be undertaken to make progress on improving integrated efforts focusing on deep-sea corals. They are organized according to the sections of the report.

Section III. Developing an *International Deep-Sea Corals Action Plan*

- Generate institutional support and obtain approval
- Organize external, joint presentations to generate cross-institution and international support
- Identify a lead coordinator for managing the development of the action plan
- Identify participants and sponsors for developing the action plan
- Organize working groups and advisory bodies
- Organize presentations for potential opponents
- Continue to formalize collaborative field operations
- Establish a working group to organize and review the results of these field operations.

Section IV. Developing a *State of the Deep-Sea Corals Report*

- Agree upon an outline
- Prepare a mockup of the report – including a template for the regional overviews
- Identify a lead for managing the development, printing, and distribution of the report
- Identify authors for the regional overviews
- Solicit support from our individual institutions.

Section V. Common Themes

- Formally identify linkages and overlapping interests for each of these topic areas/themes
- Formally identify priorities based on the list of Critical Information Needs, and based on the overlapping interests/benefits.

Section VI. Collaborative Projects

- Further assess the projects described in Appendix C to identify areas of spatial and thematic overlap and to identify additional gaps related to the Critical Information Needs
- Develop new project ideas that combine these projects, as appropriate.

Section VII. An International Transatlantic Expedition

- Develop a "Concept Paper" (draft is underway)
- Initiate regional efforts to assess existing data and establish consistent methods for new data
- Establish a centralized repository for the results of the assessments
- Develop tools to assess the results of research conducted in 2003.

IX. Additional Information Needs

Overview:
On the final day of the workshop, the group discussed information needs with regard to formalizing deep-sea coral research and conservation efforts. A strong push for public awareness (illustrating the values and threats to these environments) was recommended. Several participants suggested that the conservation of deep-sea corals through the development of an *International Deep-Sea Corals Action Plan* could result in a new paradigm for implementing ocean management strategies to protect habitats that fall outside the scope of any one nation's political jurisdiction. Such a plan could emphasize an ecosystem management approach for the benefit of multiple species, while still integrating actions focusing on single species that are facing critical declines. In an effort to maintain some momentum on three distinct but related paths – engendering political and institutional support, developing a *State of the Deep-Sea Corals Report* and an *International Deep-Sea Corals Action Plan*, and planning for an International Transatlantic Expedition – participants identified a list of Additional Information Needs:

Additional Information Needs that were identified at the workshop:

- List of educational and outreach tools and/or products that address deep-sea coral issues
- List of all published papers on the subject of deep-sea corals
- List of all enforcement tools in place that lend protection to deep-sea corals
- List of other protective legislations that may have application to deep-sea coral conservation

Marine Protected Areas:
During the workshop, a discussion regarding marine protected areas (MPAs) and their designation to protect deep-sea corals habitat generated a large amount of interest from participants. Information regarding the potential types of legislation that may help develop MPAs for deep-sea corals habitat is listed for each region:

Europe – Within the EU, the primary mechanism for establishing an MPA for deep-sea corals habitat falls under the EU *Habitats Directive*. This Directive protects aquatic species and their habitats; and supports the development of a network of *Special Areas of Conservation* (SACs). SACs have the potential to include some areas of known deep-sea corals. In addition, the EUs *Common Fisheries Policy* governs exploitation of living marine resources and can prohibit destructive fishing practices in areas that are known to contain deep-sea corals.

Canada – Canada's *Ocean Act* (1996) gives the Canada Department of Fisheries and Oceans the authority to establish MPAs to preserve and protect unique habitats, endangered and threatened species and their habitats, marine areas of high biodiversity or productivity, and other areas of the marine environment that may require special protection. For example, in Georges Bank, Nova Scotia, the Canadian government closed a 424km^2 area to bottom-impacting gear that included an area closure to protect deep-sea corals. This closure occurred as part of the 2002 Management Plan for Georges Bank groundfish. Recently, in March 2003, the Minister of Fisheries and Oceans Canada announced the designation of Endeavor Hydrothermal Vents as Canada's first MPA.

United States – In the U.S., habitat can be protected through several pieces of legislation, including the *Magnuson-Stevens Fishery Conservation and Management Act* (Magnuson-Stevens Act), the *Endangered Species Act*, the *Marine Mammal Protection Act*, and the *National Marine Sanctuaries Act*. The Magnuson-Stevens Act requires NOAA Fisheries to identify essential fish habitat (EFH) for federally managed marine fish and shellfish stocks and to regulate fishing gear that reduces EFH. EFH is defined as

habitat that is necessary for a species full life cycle (spawning, breeding, feeding, or growth to maturity). There are several different designations that NOAA can use to close a particular habitat:

(1) Federal Fishery Management Zones;
(2) Habitat Area of Particular Concern (HAPC)*;
(3) Protected Resource Zones;
(4) MPAs; and
(5) National Marine Sanctuaries

**The only area in the U.S. that was specifically closed to help protect a species of deep-sea corals is the Oculina Banks HAPC. The Oculina Banks HAPC prohibits bottom trawling, dredging, and placing fishing pots and traps on the seafloor to protect the unique ivory tree coral (Oculina varicosa).*

Executive Order (EO) 13158 signed by President Clinton on May 26, 2000 and endorsed by Commerce Secretary Evans in 2002 called for the creation of a national network of MPAs in the United States. As a part of EO 13158, a web site, mpa.gov, was launched. Mpa.gov is the venue that houses all information related to the EO and will eventually house an inventory of all marine managed areas. The *Inventory of Marine Managed Areas* will include federal, state, local or tribal areas that are regulated by law and have defined boundaries. See Figure 3 below for a map of the eleven NOAA managed MPAs on the east coast of the U.S.

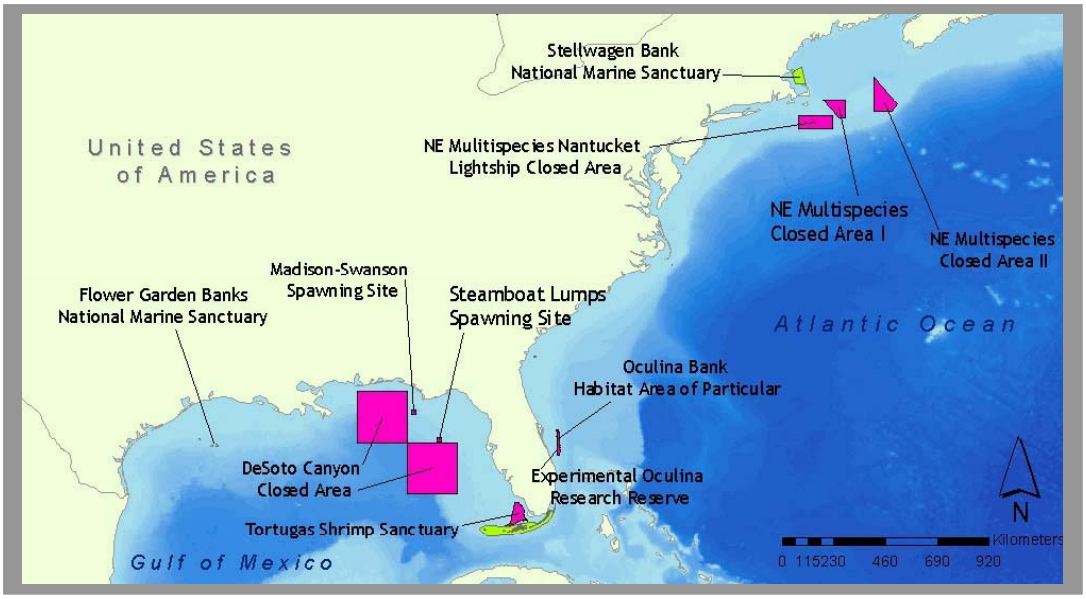

Figure 3. *Map depicting the location of the 11 NOAA managed MPAs.*

For more information regarding U.S. MPAs:

- Go to www.mpa.gov
- Click on "The MPA Inventory"
- Click on "Query the Inventory"
- Click on "Query by Site"
- Within the "Select a Single Site" section, choose a site name from the pull-down menu.
- Click on the "Search" button
- The results include a small table with some basic information about the site chosen.
- For a more detailed site profile, click on the highlighted site name within this table.

X. Conclusions

The *Deep-Sea Corals Workshop* provided an opportunity for a group of deep-sea coral researchers to discuss the need for an *International Deep-Sea Corals Action Plan*, identify critical information needs to increase our understanding of deep-sea coral ecosystems, and to identify potential collaborative efforts. The participants in the three working groups (i.e., *Mapping*, *Biology and Ecology*, and *Paleoclimate Analyses*) worked tirelessly to complete the many tasks put before them and their efforts are encapsulated in this document.

Accomplishments from the workshop include:

1. A joint "Statement of Need" for an *International Deep-Sea Corals Action Plan;*
2. Introduced the concept of developing a *State of the Deep-Sea Corals Report*;
3. Detailed descriptions of common themes for *Mapping*, *Biology and Ecology*, and *Paleoclimate Analysis* of deep-sea corals;
4. Detailed descriptions of collaborative projects for 2003 and beyond*;* and
5. Discussed the process and model for developing an *International Deep-Sea Corals Action Plan.*

Appendix A: Deep-Sea Corals Workshop Agenda

Deep-Sea Corals Workshop
January 16-17, 2003
Connemara Coast Hotel, Furbo, Galway, Ireland

AGENDA

OBJECTIVES – The objectives of this workshop are to:

1. *Reach consensus on and commitment to the development of an international "Deep-Sea Corals Action Plan"*
2. *Reach consensus on and commitment to the development of an international "State of Deep-Sea Coral Report"*
3. *Develop concise descriptions of the common exploration and research themes identified at the collaborative planning meeting held in Tampa on November 14, 2002*
4. *Develop detailed descriptions of priority collaborative efforts to undertake in 2003*

DAY 1 – ESTABLISH A FOUNDATION FOR A DEEP-SEA CORALS ACTION PLAN

8:00 BEGIN DAY 1 – Coffee

8:30 Opening *(Geoff O'Sullivan and Stephen Brown)*

8:50 Review the Agenda – Meeting Objectives and Organization *(Anthony Grehan and John McDonough)*

9:10 Round robin Introduction

9:20 **Prelude** – State-of-the-Art Summaries

- 9:20 Atlantic Coral Ecosystem Study *(Andre Freiwald)*
- 9:40 Norwegian Coral Research *(Jan Helge Fosså)*
- 9:50 U.S. Coral Research *(Kimberly Puglise)*
- 10:00 Canadian Coral Research *(Mike Risk)*

10:10 BREAK - Coffee

10:30 **Part I** – Develop an outline for a "*Deep-Sea Corals Action Plan*" *(Plenary)*

- Review existing integrated marine environmental action plans
- Discuss the need for an action plan focusing on deep-sea corals
- Develop a draft outline and establish a timeline for development

11:30 **Part II** – Develop an outline for a "*State of Deep-Sea Corals Report"* *(Plenary)*

- Review similar "State of" reports
- Discuss the report as a guide for developing an action plan
- Develop a draft outline and establish a timeline for development

12:30 LUNCH

1:30 **Part III** – Develop descriptions of common themes *(Breakout Groups)*

- Review the common themes identified in Tampa – add, delete, or change theme
- Review templates for developing descriptions
- Breakout groups develop descriptions

4:10 BREAK – Regroup in plenary

4:30 Breakout groups present descriptions to the entire group *(Plenary)*

5:30 Discuss accomplishments, next steps, and agreements *(Plenary)*

6:00 END OF DAY 1

DAY 1 Products:

1. A Working Outline of a *Deep-Sea Corals Action Plan*
2. A Working Outline of a *State of Deep-Sea Corals Report*
3. Descriptions of the Common Themes
4. Project Ideas for 2003 and 2004 (to be used on Day 2)

DAY 2 – PLANNING 2003 COLLABORATIVE PROJECTS

8:30 BEGIN DAY 2 – Coffee

9:00 Review Day 1 Accomplishments – Review the Agenda for Day 2 *(Anthony Grehan and John McDonough)*

9:30 **Part I** – Develop list of collaborative projects for 2003 *(Plenary)*

- Review the project ideas developed on Day 1
- Identify additional collaborative projects based on spatial or information gaps
- Simple classification of projects: Existing vs. New Starts

10:00 **Part II** – Prioritize collaborative projects for 2003 *(Plenary)*

- Develop a "short list" of projects based on applied criteria, i.e:
  - Addresses a critical issue
  - Addresses a critical gap
  - High potential for collaboration
  - Expected to result in information useful for the "Action Plan"
  - Financially feasible

10:30 BREAK - Coffee

11:00 **Part III** – Develop detailed descriptions of priority projects *(Breakout Groups)*

- Review project description template
- Breakout Groups (same theme areas as Day 1) develop descriptions including:
  - Project title
  - Abstract
  - Geographic area
  - Partner roles and responsibilities
  - Resource and equipment requirements
  - Actions
  - Timing and schedule
  - Anticipated costs
  - Prerequisite actions (what needs to be done immediately)

1:00 LUNCH

2:00 Continue Part III

4:00 BREAK – Coffee (Regroup in plenary)

4:30 Breakout groups present project descriptions to the entire group *(Plenary)*

5:30 Discuss accomplishments, next steps, and agreements *(Plenary)*

6:00 END OF DAY 2

DAY 2 Products:

1. Table of Project Ideas organized by theme
2. Detailed Project Descriptions
3. List of Project Ideas for consideration in out years

Appendix B: Common Themes and Critical Information Needs

This Appendix contains the detailed notes of the work conducted by each of the three breakout groups – (1) Mapping the Distribution and Abundance of Deep-Sea Corals; (2) Biology of Deep-sea Coral Ecosystems; and (3) Paleoclimate Analysis. Each of the groups was required to: 1) refine the overview statement that described their working group "theme"; 2) identify objectives for the theme (optional; not all groups listed objectives); 3) identify information needs required for making progress on their theme; and 4) further describe what the group considered to be the most "critical" information needs (i.e., those that need to be addressed as soon as possible).

Group 1: Mapping the Distribution and Abundance of Deep-Sea Corals

1. OVERVIEW STATEMENT:

In the growing research field of deep-sea corals, there is a significant need to build an information base. As a first step, deep-sea corals need to be located, charted, and their distribution and abundance estimated. The integration of GIS mapping into this process would be a useful way to synthesize the information and show the locations of research and monitoring stations, deep-sea coral habitat, and commercial fishing areas.

2. OBJECTIVES:

1. Identify the location of deep-sea corals.
2. Characterize the biotic and abiotic components of deep-sea coral habitats.
3. Characterize the geological framework of deep-sea coral habitats.
4. Evaluate and map the condition of deep-sea corals.
5. Map human activities that may impact deep-sea corals.
6. Develop and coordinate mapping strategies.
7. Develop an international geospatial data management strategy for deep-sea corals.

3. LIST OF INFORMATION NEEDS:

1. Low-resolution, large-scale surveys.
2. High-resolution, site-specific surveys.
3. Monitoring.
4. Specimen collection.
5. Acoustics method development.
6. Impacts of optical techniques on coral systems.
7. Information on human activity.
8. Who is doing what scientific research, where, and how? Are there any gaps?

4. CRITICAL INFORMATION NEEDS:

Critical Need #1 – Low Resolution, large scale mapping (>10m pixels)

Geography:

Low-resolution mapping needs to be done in many places, except for Ireland, since they have already done much of this in their own waters. The United States may need this type of work the most, as well as the continental shelf and margins off Norway. Specific regions however, were chosen for this type of mapping based on the following criteria:

- Potential marine protected areas;
- Suspected deep-sea coral areas; and
- Threatened areas.

Based on these criteria, the following areas were chosen as a sampling of the possible initial locations to perform low-resolution mapping:

- Pulley's Ridge, U.S.;
- the *Lophelia* Banks in Northeast Florida, U.S.;
- Grand Banks and George's Bank, Northeast Atlantic;
- Skaggerak, Sweden; and
- French Canyon Heads.

Technology:

The following technologies are required to meet this critical information need:

- Multibeam with backscatter; and
- Coral recognition technology.

Timing and Duration:

This work would probably be best conducted sometime from April – September. The times however would depend on the specific sites and their regional climate.

Users:

This information would be useful for almost everyone, including international organizations.

Critical Contributors:

Institution	***Contribution***
NOAA, U.S. Geological Survey	Funds, equipment
Commercial companies	Equipment
Oil and gas (MAREANO: Marine Area Database for the Norwegian Sea)	Data
Navy	Equipment, expertise
European Union	Large-scale funding
Cable, communications companies	Data
Academia	Equipment, expertise
Canadian Hydrographic Survey	Data

Critical Need #2 – High Resolution Mapping (<10 pixels)

Geography:

Specific regions were chosen for high-resolution mapping based on the following criteria:

- Potential and existing marine protected areas;
- Threatened areas;
- Suspected coral areas;
- Scientifically interesting areas; and
- Pre-existing data indicating a need.

Based on these criteria, the following areas were chosen as a sampling of the possible initial locations to perform resolution-resolution mapping:

- Northeast Passage, North America;
- West Reef, Norway;
- Rockall Bank, Ireland;
- Stellwagen Bank, U.S.; and
- Skaggerak, Sweden.

Technology:

The following technologies are required to meet this critical information need:

- Side-Scan Sonar;
- Multibeam (hi-resolution);
- Visual images;
- AUVs, ROVs, and human occupied submersibles;
- Laser Line Scan;
- Oceanographic instruments;
- Water chemistry sensors, including CTD;
- Seismic profiles; and
- Sample equipment: bottom (sediment cores).

Timing and Duration:

This work would probably be best conducted sometime from April – September. The specific times however would depend on the specific sites and their regional climate. There must be good weather/conditions to conduct this type of work.

Users:

The users would be everyone. It would be especially good to show high quality images acquired in these ways to get the public excited about deep-sea corals. This could translate into political pressure and potentially more funding.

Critical Contributors:

Institution	***Contribution***
NOAA (through NOAA's Undersea Research Program and the Office of Ocean Exploration)	Funds, equipment (ROVs, AUVs, and submersibles)
U.S. Geological Survey	Acoustic profiling
European universities	Large-scale equipment
European Union	Large-scale funding
Cable, communications companies	Data
Academia	Equipment, expertise
Canadian Hydrographic Survey	Data
Oil and gas companies	Data

Group 2: Biology of Deep-Sea Coral Ecosystems

1. OVERVIEW STATEMENT:

A. Physiological ecology of habitat-forming coral species

Improving the basic knowledge of deep-sea coral physiological ecology is a significant need to better understand these organisms. Several fundamental questions have yet to be answered regarding the physiology of deep-sea corals. What controls growth and development? Improving the knowledge of coral biology as it relates to feeding, behavior, and genetics is a priority to better understand these organisms. What are the abiotic and biotic factors that influence reproduction and dispersal? How do abiotic and biotic factors affect deep-sea coral distribution and abundance and their associated flora and fauna? In situ experiments and those using aquaria may provide insight into the sensitivities and tolerance of deep-sea corals to anthropogenic changes.

B. Ecology of Deep-Sea Coral Communities

Deep-sea coral habitat supports a diverse array of fish and invertebrate species. Current research interests are to assess reef biodiversity, food web relationships, and the importance of deep-sea corals as refugia for fish and invertebrates to spawn, breed, feed, and grow to maturity. There is a need to describe the diversity of associated fauna and the role that deep-sea habitat plays in their life histories (growth rates, age of sexual maturity, fecundity, spawning frequency, and recruitment).

C. Biogeographic and Taxonomic Studies

Many deep-sea coral and associated fauna species and species complexes are still unknown. In addition, biogeography and its driving processes also remain poorly understood. Taxonomic expertise needs to be developed. Molecular genetic studies may provide insight into measuring coral larval dispersal. Genetic studies may be used to compare corals and associated fauna both regionally, as well as trans-Atlantic.

Note: Based on the results of the *Deep-Sea Corals Collaboration Planning Meeting* held in Tampa, three common themes (taxonomy, physiology, and ecology) were to be discussed independently of one another. However, prior to this workshop, a decision was made to consider the three common themes within one working group. After some discussion, the working group agreed to create an overarching heading (i.e., Biology of Deep-Sea Coral Ecosystems) that would incorporate all three common themes as subtopics. Additionally, it was suggested by the working group that there was a significant need for an additional common theme entitled "Characterization of the Physical and Chemical Environment". This common theme would enable us to address the development of new tools to assess, characterize, monitor, etc. The group agreed that it is a context from which every common theme, and the topics within them, would benefit.

2. OBJECTIVES:

None stated.

3. LIST OF INFORMATION NEEDS:

A. Physiological ecology of habitat-forming coral species

1. Larval biology and reproductive ecology.
2. Coral food web.

3. Life and death of a reef (i.e., succession, disturbance, competition, bioerosion).
4. Recolonization of disturbed areas.

B. Ecology of Deep-Sea Coral Communities

1. *Lophelia* ecosystem function, especially as it relates to fish habitat.
2. Colonization and dispersal of corals and associated fauna, especially sessile fauna.
3. Habitat preferences.
4. Thermal physiology (i.e., tolerance).
5. Sediment stress.
6. Quantitative description of associated fauna.
7. In situ monitoring of the environment at multiple spatial levels (i.e., local to regional), including description of the local environment.
8. $\alpha-\beta-\gamma$ Biodiversity estimated at different scales.
9. Coral growth (ex. rates of calcification, carbon and energy budgets).
10. Natural history interactions and symbiosis (ex. polychaetes and coral interactions).
11. Targeted lab studies based on in situ studies.
12. Recruitment using molecular markers.
13. Life and death of a reef (i.e., succession, disturbance, competition, bioerosion).
14. Recolonization of disturbed areas.

C. Biogeographic and Taxonomic Studies

1. Taxonomic expertise and access to taxonomic network to be able to do comparison studies.
2. Species definition (i.e., genetics and molecular systematics).

4. CRITICAL INFORMATION NEEDS:

Critical Need #1 – Growth and Reproduction

Note: To describe the whole life span of a polyp, we need to understand deep-sea coral growth rates. The working group discussed the potential cross over of interests and objectives with Group 3: *Paleoclimate Analysis*. Also, the group discussed that this critical information need could be listed within the "Characterization of the Physical and Chemical Environment" theme recommended by this group as an addition to the common themes list.

Geography:

Efforts should be focused in the following regions:

- Norwegian Sea;
- Sweden;
- France/Ireland;
- Portugal/Spain;
- NE Atlantic of North America; and
- Gulf of Mexico.

Specific sites were chosen based on ease of sampling:

- Trondhjem Fjord, Norway;
- NE Gulf of Mexico, U.S.;
- Blake Plateau, U.S.; and
- Porcupine Bight, France and Ireland.

Technology:

The following technologies are required to meet this critical information need:

- Visual images;
- AUVs, ROVs, and human occupied submersibles;
- Oceanographic instruments;
- Water chemistry sensors, including CTD;
- Bottom sampling equipment; and
- Lab facilities, including aquaria.

Timing and Duration:

Ideally, information should be collected spanning all months of the year. It will require several years to collect this data. Additionally, short-term lab studies will be necessary to calibrate field-collected data.

Users:

- Scientific Community; and
- Commercial Interests, including the Fishing Community, Gas & Oil, and Government.

Critical Contributors:

Institution	***Contribution***
NOAA's Undersea Research Program National Science Foundation	Funds, Equipment
Scottish Association for Marine Science	Growth/Budgets
Oregon Institute of Marine Biology, Southampton Oceanography Centre, University of South Hampton, University of Maine	Reproduction

Critical Need #2 – Food Web and Species Interactions

Geography:

The location of this work should be based on ongoing efforts and along a latitudinal gradient.

Technology:

- Visual images;
- AUVs, ROVs, and human occupied submersibles;
- Oceanographic instruments;
- Bottom sampling equipment, including benthic landers;
- Sample equipment: nets;
- Biological samples; and
- Lab-based studies.

Timing and Duration:

This may be ecosystem-dependent (e.g., fish aggregations/spawning on Oculina Banks happen in February - March; there are spring phytoplankton blooms/surface productivity and seasonally-dependent fish associations).

Users:

- Scientific Community.

Critical Contributors:

The main funding arena for this theme will be fishery-related.

Institution	***Contribution***
University of Maine, University of Connecticut	Essential Fish Habitat
McMaster University and Dalhousie University	Food web, Stable Isotope Genetics
University of Groningen (RUG)	Trophic Diversity
Scottish Association for Marine Science	Deep-sea Fisheries & Species Interactions
University of Liverpool	Isotopes & Lipid Biomarkers
University of North Carolina at Wilmington & Florida State University	Food Web
Monterey Bay Aquarium Research Institute	Stable Isotopes & Lipid Biomarkers
Institute of Marine Research, Norway	Fish Habitat & Community Analysis
National University of Ireland, Galway; Irish Marine Institute	Stable Isotopes & Fisheries

Critical Need #3 – Species Inventory and Development of Taxonomic Tools

Geography:

- Global.

Technology:

- AUVs, ROVs, and human occupied submersibles;
- Bottom sampling equipment;
- Molecular systematics;
- Gene probes; and
- α taxonomy.

Taxonomic expertise:

The working group discussed the need for a mechanism(s) for sending specimens to experts. The idea is develop a clearinghouse to prevent deep-sea coral taxonomy experts from being overwhelmed with samples to identify. The bulk of reef species could be assigned to local scientists, saving the difficult species for taxonomists.

Timing and Duration:

This is not relevant to this critical need.

Users:

- Governments, including species protection programs.
- Commercial interests, including the biotechnology industry.

Critical Contributors:

The deficit in capable taxonomists is an issue that continues to be raised at European Union meetings, but at present no money is available.

Institution	***Contribution***
Smithsonian Institution	Taxonomists and repository
National University of Ireland, Galway; Census of Marine Life	Taxonomy and data collecting
National Institute for Undersea Science and Technology at the University of Mississippi	National repository for collecting and cataloging biological, taxonomic, genomic, and chemical data of organisms.
University of Charleston	Molecular systematics
University of Galway	Deep-sea species
Oil & Gas industry, National Science Foundation	Funding of taxonomy fellowships

Group 3: Paleoclimate Analysis

1. OVERVIEW STATEMENT:

Paleo-retrospective and prospective analysis may be a tool to separate natural oscillations versus anthropogenic effects. Information derived from paleontological studies will allow modelers to assess climate change. Paleontological studies will also assist fisheries managers to determine whether any changes seen in fish stock assessments are likely a result of natural variations in climatic, oceanographic conditions, and/or anthropogenic stressors.

Note: **Why use deep-sea corals as paleoclimate proxies?**

1. They have a better time resolution than sediment cores (± 1 year versus ± 500 years).
2. Gorgonians can provide temperature and productivity data.
3. Ice cores are restricted to polar regions.
4. Reef corals are restricted to the tropics and shallow regions.
5. Deep-sea corals occur in all oceans and at all depths.
6. Deep-sea corals are not affected by bioturbation, a problem that plagues sedimentary core records using foraminiferans.

2. OBJECTIVES:

Overarching Goal: To model and predict future climate changes by ascertaining past environmental conditions through retrospective analysis.

1. Modelling future climate change.
2. Fisheries management: understand previous environmental conditions, such as temperature and salinity, to hypothesize historical fish populations.
3. Risk assessment management: use paleoclimate research capabilities to help predict disastrous weather events and tap risk assessment agencies (e.g. insurance companies) for funding.
4. Link changes in biodiversity with climate change.
5. Obtain salinity measurements separately from temperature records (for the purpose of oceanographic modelling)
6. Translate the recorded paleoclimate data in a useful and useable way for climate modelers.
7. Measuring CO_2 dissolution in the oceans. This is critical since CO_2 is the highest it has been in years. We need to determine how this affects climate, how quickly the CO_2 can dissolve, and where it is going.
8. Gather long-term records.
9. Teleconnections ─ A buzzword and term widely used to describe the complex feedback patterns involved in long distance processes where the effect of an environmental event (e.g. oceanographic/atmospheric process) occurring in one place also shows up in another (e.g. African dust).

3. LIST OF INFORMATION NEEDS:

1. Low-resolution, large-scale surveys.
2. High-resolution, site-specific surveys.
3. Specimen collection and analysis.
4. Piggyback cruise website.
5. International Gulf Stream cruise.
6. Sampling consistency and experiment planning.
   • There is a need to more carefully examine experimental and statistical design beforehand and to make sure that replicates are truly replicates.

• It is more important to select those sites that will provide the most informative paleoclimate-related data rather than selecting sites based on quantity or other reasons.

7. Linkages between biodiversity and climate change.
8. Human resource exchange.
9. Time-series of hydrographic changes.

4. CRITICAL INFORMATION NEEDS:

Critical Need #1 – Samples from areas that are of key Transatlantic climate importance

Geography:

A Gulf Stream transect is necessary. Possible sampling sites for a Gulf Stream expedition include the following:

- Faroes-Shetlands Channel;
- NE Channel (North Atlantic Oscillation);
- Orphan Knoll (return flow);
- Blake Plateau;
- Seamount of Gibraltar- Seine Seamount;
- Sedlo Seamount;
- Lofoten Islands;
- Hatton Bank; and
- Rockall Trough.

Technology:

The following technologies are required to meet this critical information need:

- Visual images;
- AUVs, ROVs, and human occupied submersibles;
- Oceanographic conditions (CTD);
- Water chemistry sensors;
- Sample equipment;
- Cores;
- Isotope lab;
- ICP/MS labs; and
- Climate modelers.

Timing and Duration:

This work needs to be performed only once and can happen at any time of year.

Users:

There are several different users who could use this information.

Critical Contributors:

Category not discussed at workshop.

Critical Need #2 – Controlled Growth Experiments to Calibrate Geochemical Signals and Relevant Water Mass Properties.

Geography:

- Global.

Technology:

The following technologies are required to meet this critical information need:

- Aquarium;
- Analytical laboratory capabilities; and
- Isotope laboratory for dating.

Timing and Duration:

The fieldwork should be performed sometime within the months of July - September. One successful trip would be sufficient, but coral survival is important.

Critical Contributors:

Category not discussed at workshop.

Critical Need #3 – Good Hydrographic Data

Geography:

- Gulf Stream.

Timing and Duration:

The longest available time series should be acquired.

Users:

There are several different users who could use this information.

Critical Contributors:

Category not discussed at workshop.

Appendix C: Project Descriptions

During the first day of the workshop, participants were divided into breakout groups where they identified current and proposed projects relating to deep-sea corals. The individual who identified each project was then asked on the second day to further describe their project(s). This information was collected through a questionnaire onto which the participants hand-wrote the details of their project. The table that follows is a compilation of the most salient points of these projects and includes the following categories grouped under the most relevant common theme:

- *Timing:* When the projects will/may take place. This category is divided into 2003 projects and future projects.
- *Location:* The region of study is categorized as U.S., Canada, Europe, and Multi-regional. The four categories may be further described by specific sites or reefs.
- *Description:* Very brief abstract of the project.
- *Key Activities:* Brief descriptions of the primary activities that will take place during the project.
- *Contact:* Principal- or Co-Investigator of the project or an individual with information on the project

MAPPING		
	United States	
PROJECT YEAR	**2003**	
Project	**Description**	**Key Activities**
Habitat Characterization of the Oculina Banks Marine Protected Area **Timing:** **2003** **Location:** **US – South Atlantic Bight**	A multibeam survey of the Oculina Banks was recently completed, and the data, as well as other complementary data sets, have been incorporated into an Oculina Geographic Information System (GIS). In 2003, NOAA and NASA will partner to further characterize the fish and habitat in the Oculina Marine Protected Area. An ROV will explore new sites of potential bioherms discovered during the multibeam survey. Current habitat maps will be expanded, refined, and incorporated into the GIS. The multidisciplinary team includes fishery biologists, geologists, and a benthic ecologist from Scotland. **Contact: Andy Shepard** **E-mail: sheparda@uncw.edu**	• Random video transects on unexplored target features identified from the multibeam survey using an ROV • Semi-annual cruises • Development of acoustic technologies to monitor vessels and fish aggregations
PROJECT YEAR	**FUTURE**	
Project	**Description**	**Key Activities**
OASIS -- Ocean Seamounts - An Integrated Study **Timing:** **Future – Multiyear** **Location:** **Mid-Atlantic Ridge**	This effort will focus on ecosystem zonation and dynamics on two selected mid-Atlantic Seamounts. The project will use a multidisciplinary approach including oceanography, hydrography, seabed mapping, MOCNESS, ROV, fishing, etc. **Contact: Andre Friewald** **E-mail: Andre.Friewald@pal.uni-erlangen.de**	• Assessment of biodiversity from the summits to the deep floor of seamount ecosystem(s)
Gulf of Maine Mapping **Timing:** **Future** **Location:** **Gulf of Maine**	The 70-foot NOAA R/V *Gloria Michelle* is berthed in Woods Hole, Massachusetts. Funds are still being sought to equip the vessel with a multi-beam system. The vessel may be available at low-cost for 30-days/year, and will focus on mapping areas in the Gulf of Maine. **Contact: Michael Sissenwine** **E-mail: Michael.Sissenwine@noaa.gov**	• Conduct near-shore mapping in the Gulf of Maine • Collect sediment and biological samples for analysis • Collect video data for ground truthing

MAPPING

EUROPE

PROJECT YEAR 2003

Project	Description	Key Activities
Norwegian Coral Mapping **Timing:** **2003** **Location:** **Norwegian Sea**	Mapping (high- and low-resolution) and ground truthing of *Lophelia* corals. Physical and geological characterization of the Rost Reef area. **Contact: Jan Helga Fosså** **E-mail: jhf@imr.ie**	• Develop routines for the use of mapping systems • Ground truth multibeam maps using ROVs and a drifting camera • Identify coral distribution and growth patterns • Compare video collected at the Rost Reef area with video collected at Sula Ridge and other known deep-sea coral habitats
Mapping of cold-water corals in the Skagerrak **Timing:** **2003 – Multiyear** **Location:** **Sweden** **North Sea**	On-going mapping activities by means of single- and multi-beam bathymetry, and ROV-surveys and side-scan sonar surveys (partly depending on pending financing). Monitoring on a regular basis of selected reef sites. **Contact: Tomas Lundalv** **E-mail: tomas.lundalv@tmbl.gu.se**	• Frequent 1-day cruises with R/V *Lophelia* pending proposals
Irish National Seabed Survey (INSS) **Timing:** **2003 – Multiyear** **Location:** **Ireland – Continental Shelf**	The INSS is an Irish Government funded (32M euros) seven-year project to the Irish continental shelf. It is managed by the Geological Survey of Ireland. Mapping of Zone 3 (4,000m – 200m) has been completed and work is now commencing on Zone 2 (200m – 50m). Data being gathered includes, multibeam sonar, sub-bottom profiling, magnetics, gravity, CTD, Sound Velocity Profile, video and camera ground-truthing, and side-scan sonar in the shore areas. The project began in 1999 and runs until 2005. Ancillary projects include cetacean and bird observations. **Contact: Michael Geogheran** **E-mail: michaelgeogheran@gsi.ie**	• Survey water depths between 50-200m • Collect samples and analyze for geochemical and biological properties

PROJECT YEAR FUTURE

Project	Description	Key Activities
MAREANO (Marine Area Database for the Norwegian Sea) **Timing:** **Future** **Location:** **Barents Sea**	MAREANO is a 5-year mapping and data analysis effort that includes the development of a marine area database of the Norwegian continental shelf and coast. **Contact: Jan Helga Fosså** **E-mail: jhf@imr.no**	• Conduct multibeam mapping • Assess data for geological resources, bottom conditions, habitats, biodiversity, and potential pollution

MAPPING

EUROPE (cont.)

PROJECT YEAR FUTURE

Project	Description	Key Activities
National University of Ireland, Galway - Higher Education Authority Deep Sea Habitat Mapping Cruise **Timing:** **Future** **Location:** **Porcupine Bank**	Develop cost-efficient ground-truthing survey methodology using ROVs to add habitat information to inferred substrate from Irish National Seabed Survey multibeam backscatter data. **Contact: Anthony Grehan** **E-mail: anthony.grehan@nuigalway.ie**	• Conduct a high-resolution multibeam video survey to characterize areas with different multibeam backscatter characteristics • Collect voucher specimens to correlate species with video survey
6th EU-Framework Programme "Ocean Margin Life" **Timing:** **Future** **Location:** **Norwegian Sea** **Sweden** **Porcupine Bank** **Portugal – Spain** **Mediterranean Sea**	Understanding biodiversity and ecosystem dynamics in relation to global change depicted from deep-water coral habitats -- to be streamlined in late 2003 **Open to Transatlantic Networking! **Contact: Andre Friewald** **E-mail: andre.friewald@nal.uni-erlangen.di**	• Conduct high-resolution seabed mapping of new coral • Collect physical, biogeochemical, and hydrogeographic data at and near coral habitats

MULTI-REGIONAL

PROJECT YEAR 2003

Project	Description	Key Activities
Mapping Inshore Coral Habitats **Timing:** **2003** **Location:** **Gulf of Mexico** **Sweden** **North Sea**	Survey, map, and assess the viability of cold-water coral in the Minches (Hebridean Sea), and other regions. **Contact: Murray Roberts** **E-mail: m.Roberts@dml.ac.uk**	• Sample dead standing coral for identification of associated fauna • Sample sediment for microbial analysis • Sample live coral for analysis of reproductive state and growth bands, plus aquarium projects and isotopes • Deploy current meter close to reef to document associated pelagic megafauna

PROJECT YEAR FUTURE

Project	Description	Key Activities
Managing Deep-Water Coral Protected Areas **Timing:** **Future** **Location:** **Eastern Canada** **North Sea** **Norwegian Sea**	Map the intensity of fishing effort in deep-sea coral areas where fishing vessels are monitored by satellite tracking technology. **Contact: Jason Hall-Spencer** **E-mail: gbfa20@udcf.gla.ac.uk**	• Map fishing intensity in coral provinces of the NE Atlantic • Analyze the information obtained from the European Union Vessel Monitoring Scheme

BIOLOGY AND ECOLOGY

UNITED STATES

PROJECT YEAR 2003

Project	Description	Key Activities
Lophelia Ecosystem Food-Web in the Northeast Gulf of Mexico **Timing:** **2003** **Location:** **Gulf of Mexico**	This project aims to study the fish fauna (FONS web) associated with the *Lophelia* coral communities with emphasis on their abundance, food intake (trophodynamics) and to recover live *Lophelia* colonies for laboratory studies on coral-feeding, metabolism and tolerance of thermal stress. **Contact: Bob George** **E-mail: george@uncwil.edu**	• Establish 2 study-sites on the DeSoto Slope • Use ROV with tethered monitoring system (TMS) for selectively taking live *Lophelia* coral • Develop a 1km transect and conduct photo-survey where fish aggregations are located

PROJECT YEAR FUTURE

Project	Description	Key Activities
NE Gulf of Mexico Shelf-edge Habitats **Timing:** **Future** **Location:** **Gulf of Mexico**	Several short (1-3 day) cruises will be taken to observe grouper spawning aggregations and to collect video with an ROV to "ground truth" in areas with previously collected side scan sonar &/or multibeam bathy data. A small (~60') boat will be hired. Some sediment grab samples may be collected. **Contact: Kathy Scanlon** **E-mail: kscanlon@usgs.gov**	• ROV with video camera will be used to observe fish behavior and habitat • Sediment samples may be collected in some areas using a modified Van Veen grab sampler

CANADA

PROJECT YEAR 2003

Project	Description	Key Activities
Deep Corals of the North Atlantic, George's Bank Shelf Edge **Timing:** **2003** **Location:** **Eastern Canada**	Coral forests of gorgonian populations live all along the seaward edge of George's Bank and in the canyons. Similar dense coral populations likely lived in shallower waters at one time, but are now rare, likely due to intensive trawling activity. This project will characterize coral habitat and determine if the deep corals serve as a source of new recruitment to shallower, recently protected areas. **Contact: Mike Risk** **E-mail: riskmj@mcmaster.ca**	• Random video transects on suspected coral beds using an ROV • Explore targets identified from multibeam that may harbor coral habitat using an ROV

EUROPE

PROJECT YEAR 2003

Project	Description	Key Activities
ACES - Biodiversity and Ecosystem Dynamics **Timing:** **2003** **Location:** **Norwegian Sea** **North Sea** **Porcupine Bank**	This project will describe coral ecosystem, dynamics and functioning as part of the larger European Atlantic Coral Ecosystem Study (ACES). **Contact: Murray Roberts** **E-mail: m.roberts@dml.ac.uk**	• Collect hydrographic data • Deploy the "Photo Lander" for ground truthing • Aquarium-based assay of physiology and response to sedimentation (*Lophelia*) • Faunal description and analysis of samples

BIOLOGY AND ECOLOGY

EUROPE (cont.)

PROJECT YEAR 2003

Project	Description	Key Activities
EURODOM -- Thematic Network on European Deep-Ocean Margin **Timing:** **2003** **Location:** **Ireland** **Bay of Biscay** **Mediterranean**	This project has a Ph.D. position open with 3-year funding, dedicated to biodiversity studies linked with geochemistry. **Contact: Andre Friewald** **E-mail: andre.friewald@nal.uni-erlangen.di**	• Assessment of biodiversity of coral-associated fauna over a wide latitudinal spread • Develop a Web-based database • Develop a functional-trophic model of coral habitats
GeoLab **Timing:** **2003** **Location:** **Porcupine Bank**	Development and deployment of a long-term benthic observatory on the Porcupine Sea bight. **Contact: Andre Friewald** **E-mail: andre.friewald@nal.uni-erlangen.di**	• Develop a long-term benthic observatory to detect daily to annual environmental changes within a selected coral mound • Use multi-sensor technologies including satellites

PROJECT YEAR FUTURE

Project	Description	Key Activities
"Moundforce" **Timing:** **Future** **Location:** **Sweden** **Porcupine Bank** **Mediterranean**	Understand the timing of the onset of coral ecosystem evolution during the last glacial-interglacial transition until recent. Study sites will cover formerly glaciated, peri-glaciated and non-glaciated coral reefs. **Contact: Andre Friewald** **E-mail: andre.friewald@nal.uni-erlangen.di**	• Retrieve high-quality sediment cores from the relevant study sites • Geochemistry on selected species and both benthic and planktonic forms • Develop core descriptions • Identify key species that changed with the changing climate along other continental margins
Quantification of Skeletal Carbonate Degeneration through Bioerosion **Timing:** **Future** **Location:** **Sweden**	Experimental study on bioerosion driven by bacteria, fungi, algae, sponges, etc. from the intertidal zone to aquatic depths. **Contact: Tomas Lundalv** **E-mail: tomas.lundalv@tmbl.gu.se**	• Deployment and recovery of skeletal parts with ROV • Taxonomic assessment of bioeroders backed-up with molecular genetics
MARBIPP (Marine Biodiversity, Patterns and Processes) **Timing:** **Future** **Location:** **Norwegian Sea** **Sweden**	This project will examine aspects of biodiversity in relation to cold-water coral assemblages (genetic, specific functional goods and services), and the effects of fragmentation to describe reef genetic variability between and within. **Contact: Tomas Lundalv** **E-mail: tomas.lundalv@tmbl.gu.se**	• Studies of video-identifiable megafauna in relation to coral assemblages of variable size and location and adjacent habitats • Comparison of catches from different types of coral habitats and other types of habitats • Analysis of macrofauna along transects radiating from coral patches

BIOLOGY AND ECOLOGY

EUROPE (cont.)

PROJECT YEAR FUTURE

Project	Description	Key Activities
Higher Education Authority Project - Benthic Community and Taxonomy Research **Timing:** **Future** **Location:** **Ireland**	Extension of Benthic Community Research into deep-water and deep sea; Integration of traditional sampling with sediment profile imaging; training of post-graduate in taxonomy. **Contact: Anthony Grehan** **E-mail: anthony.grehan@nuigalway.ie**	• To collect bottom samples for taxonomic analysis of benthic macrofauna • Establish species collections of deep-sea fauna

MULTI-REGIONAL

PROJECT YEAR 2003

Project	Description	Key Activities
Comparison of Megafauna Between High & Low Latitude *Lophelia* Reefs **Timing:** **2003** **Location:** **All**	Analysis of megafauna from video records taken along transects across *Lophelia* reefs off the mid-Norwegian coast and the Gulf of Mexico. Discussion of ecological roles of the dominant taxa. **Contact: Pal Mortensen** **E-mail: mortensenp@mar.dfo-mpo.gc.ca**	• Conduct video recording along transects • Develop standardized analysis to provide quantitative estimates of densities and percentage cover • Analyze existing material collected in the Norwegian Sea in relation to new records taken in the summer 2003 at the Rost Reef
Populations of *Lophelia pertusa* from Swedish West coast versus Blake Plateau: Eco-physiological and genetic differences **Timing:** **2003** **Location:** **Sweden** **South Atlantic Bight** **Gulf of Mexico**	(1) Determine thermal tolerance and metabolism; (2) IbsrRNA - gene sequencing for establishing population differences; (3) establish food web of *Lophelia* community; (4) define differences in *Lophelia* communities between high- and mid-latitude ecosystems (Swedish and North Carolina (U.S.) coast) (5) use light and baited traps to compare scavenger biodiversity between *Lophelia* reef off Sweden, US South Atlantic Bight, and NE Gulf of Mexico. **Contact: Bob George** **E-mail: george@uncwil.edu**	• Collect photos to establish core density and associated fish invertebrate fauna • Collect live corals to be transferred in temperature-controlled aquaria for a series of lab experiments • Under UV light filter/conditions, the demersal zooplankton (fish larvae and peracarid crustaceans) will be trapped for microscopic study of species composition and richness

PROJECT YEAR FUTURE

Project	Description	Key Activities
Carbon and Energy Budgets for *Lophelia* **Timing:** **Future** **Location:** **All**	Develop descriptive models of cold-water coral growth, respiration, and reproduction. Relate to reef growth and development observed in field. **Contact: Murray Roberts** **E-mail: m.roberts@dml.ac.uk**	• Video-directed grab using ROVs and submersibles • Maintain live corals in lab • Conduct experiments: closed-chamber oxygen consumption, growth - buoyant weight, food budget - CHN analysis • Develop a simple model of Carbon and energy flows • Relate results to in situ monitoring observations - local scale physics - chemical environment

BIOLOGY AND ECOLOGY

MULTI-REGIONAL (cont.)

PROJECT YEAR FUTURE

Project	Description	Key Activities
Reproductive Cycles of *Lophelia pertusa* in the NE Gulf of Mexico and Trondheim fjords **Timing:** **Future** **Location:** **Norwegian Sea** **Gulf of Mexico**	Samples will be taken periodically from the NE Gulf of Mexico and the Fjords of Trodheim in Norway. Samples will be analyzed using standard histological techniques and micro dissection for determination of gametogenic samples and fecundity. **Contact: Sandra Brooke** **E-mail: sbrooke@oimb.uoregon.edu**	• Collect specimens of live coral • Conduct analysis of reproductive cycles
Coral Landers **Timing:** **Future** **Location:** **All**	Develop Techniques, technology, and deployment of benthic landers to study cold-water coral reefs. **Contact: Murray Roberts** **E-mail: m.roberts@dml.ac.uk**	• Develop self-contained video operating with infrared illumination. • Develop stable and robust landers for cold-water coral environment and capable of deployment in coral rubble zones • Develop logging units to deploy in trawled areas • Develop techniques to log zooplankton
NOAA's Undersea Research Program (NURP) – AUV for Habitat Characterization on the Continental Margin **Timing:** **Future** **Location:** **All**	NURP now has the funding to purchase an AUV to support NOAA's mission. Led by the NURP center at the University of North Carolina at Wilmington, a preliminary requirements analysis is underway to define the priority research needs and desired capabilities. The vehicle should be available for partnership efforts in 2004. **Contact: Andy Shepard** **E-mail: sheparda@uncw.edu**	• Design an AUV capable of habitat characterization and mapping to depths of 1000m • Design an AUV capable of handling multibeam, side-scan sonar, and CTD with open ports for optional sensors

PALEOCLIMATE

MULTI-REGIONAL

PROJECT YEAR FUTURE

Project	Description	Key Activities
Predicting Abrupt Thermohaline change in the North Atlantic **Timing:** **Future** **Location:** **Gulf Stream & Currents**	Calcified organisms, including cold-water corals, are being used to determine past fluctuations in the Gulf Stream to help predict the effects of climate change on global ocean currents. This project would require the collection of voucher specimens of specific deep-sea coral species from the Gulf of Mexico to the Norwegian Sea for paleoclimate analysis. **Contact: Mike Risk** **E-mail: riskmj@mcmaster.ca**	• Collect samples required from the U.S. and Canadian side of the Gulf Stream • Collect samples from Europe • Lengthy lab-bases analysis of the skeletal chemistry of calcified algae, bivalves, and corals

MULTI-DISCIPLINARY

UNITED STATES

PROJECT YEAR 2003

Project	Description	Key Activities
Distribution and Ecology of *Lophelia pertusa* reef systems in the NE Gulf of Mexico **Timing:** **2003** **Location:** **Gulf of Mexico**	The primary objective of this project is to explore and map several new areas of potential coral habitat in the NE Gulf of Mexico. These will subsequently be ground-truthed using a submersible with video. A megafauna species inventory of reef-associated fauna will be taken using video and time-lapse cameras. (This will be compared with those taken from Norwegian seas to investigate latitudinal differences in faunal associations). Microbial communities will be described. Live and dead coral samples will be taken for faunistic association and analysis of growth and reproductive state. **Contact: Sandra Brooke** **E-mail: sbrooke@oimb.uoregon.edu**	• Map identified areas of potential coral habitat and deploy current meter • Georeference and ground-truth maps of new areas • Take close-up video (with lasers for size reference) of coral for identification of coral-associated megafauna • Take samples of dead standing coral for identification of associated fauna and microbial analysis • Take samples of live coral for analysis of reproductive state and growth bands, plus aquarium projects and isotopes

CANADA

PROJECT YEAR FUTURE

Project	Description	Key Activities
Deep-Sea Corals Research Network **Timing:** **Future** **Location:** **Canada**	The proposal addresses 4 topics: (1) high-resolution paleoclimate studies in the deep-sea; (2) chemical and biological studies of deep-sea corals; (3) the ecology of deep-sea corals habitats and the effects of fishing; and (4) education and public outreach. **Contact: David B. Scott** **E-mail: dbscott@dal.ca**	• Analyzing carbon/nitrogen ratios and isotopes in deep-sea corals • Collect live corals and conduct controlled experiments • Habitat mapping using • Educational videos

EUROPE

PROJECT YEAR 2003

Project	Description	Key Activities
Victor ROV cruise - Polarstern 2003 **Timing:** **2003** **Location:** **Ireland**	ROV observation of giant carbonate mounds in the Porcupine Sea bight and Porcupine Banks in Ireland. Looking at biodiversity, organism interactions, environmental controls on normal growth, hydrocarbon cold seeps (if present), and mapping. **Contact: Andy Wheeler** **E-mail: a.wheeler@ucc.ie**	• High-resolution multibeam mapping of mound morphology • Observation of biological and geological features • Sampling biota, sediments, isotopes, and gas hydrates • Long-term monitoring of biological and environmental factors

PROJECT YEAR FUTURE

Project	Description	Key Activities
Environmental Sensitivity of Cold-Water Corals **Timing:** **Future** **Location:** **North Sea**	To study occurrence of *Lophelia pertusa* on North Sea oil platforms in relation to drilling discharge exposures. **Contact: Murray Roberts** **E-mail: m.roberts@dml.ac.uk**	• Establish a GIS and database • Develop c/o isotope profile, 2A-ICP-MS element profile, hydrocarbon analysis • Hydrodynamics and particle flux logging • Study live *Lophelia*: Growth, respiration, response to stress • Integration of data to inform conservation management

Appendix D: Participant List

NAME	AFFILIATION	PHONE #	EMAIL ADDRESS
Margot Bohan	NOAA Office of Ocean Exploration	+301.713.9444 ext.130	margot.bohan@noaa.gov
Robert Brock	NOAA Fisheries	+301.713.2363 ext.162	robert.brock@noaa.gov
Sandra Brooke	Oregon Institute Marine Biology, USA	+541.888.2581 ext.318	sbrooke@oimb.uoregon.edu
Colin Brown	National University of Ireland, Galway	+353.91.52.44.11	colin.brown@nuigalway.ie
Steve Brown	NOAA Fisheries	+301.713.2363 ext.133	stephen.k.brown@noaa.gov
Bryan Deegan	ALTEMAR (working with the Irish Marine Institute)	01-2010713	bryan@ALTEMAR.IE
Lisa Fitzpatrick	Irish Marine Institute	+353.91.730.428	lisa.fitzpatrick@marine.ie
Jan Helge Fosså	Institute of Marine Research	+47 55.23.85.00	jhf@imr.no
André Freiwald	Institute for Paleontology, Erlangen University, Germany	+49 9131-8526959	Andre.freiwald@pal.uni-erlangen.de
Michael Geoghegan	Geological Survey of Ireland	+353.1.678.28.40	michaelgeoghegan@gsi.ie
Bob George	University of North Carolina, Wilmington/GIBS George Institute for Biodiversity	+910.799.4722	georgeryt@cs.com
Anthony Grehan	National University of Ireland, Galway	+353.91.512.004	anthony.grehan@nuigalway.ie

Jason Hall-Spencer	The Royal Society	00.44.141.248.7557*	gbfa20@udcf.gla.ac.uk / jhall.spencer@hotmail.com
Kristin Heron	NOAA Office of Ocean Exploration/ National Ocean Service	+301.713.9444 ext. 141	kristin.heron@noaa.gov
Gerd Konnecker	National University of Ireland, Martin Ryan Science Institute, Galway	+353.91.52.44.11 ext.3219	gerd.koennecker@nuigalway.ie
Tomas Lundalv	Tjarnoe Marine Biological Laboratory, Sweden	+46 52.66.86.67	tomas.lundalv@tmbl.gu.se
Melanie Mercer	Irish Marine Institute		melanie.mercer@marine.ie
John McDonough	NOAA Office of Ocean Exploration	+301.713.9444 ext. 113	John.mcdonough@noaa.gov
Xavier Monteys	Geological Survey of Ireland	00.35.31.67.82.840	xaviermonteys@gsi.ie
Pal B. Mortensen	DFO, Canada	19.02.426.99.17	mortensenp@mar.dfo-mpo.gc.ca
Michael O'Cinneide	Irish Marine Institute	+353.91.730.400	michael.ocinneide@marine.ie
Laura Oremland	NOAA Fisheries	+301.713.2363 ext. 151	laura.oremland@noaa.gov
Geoffrey O'Sullivan	Irish Marine Institute	+353.1.47.66.500	gosullivan@marine.ie
Kimberly Puglise	NOAA's Undersea Research Program	+301.713.2427 ext.199	kimberly.puglise@noaa.gov
Mike Risk	MacMaster University, Canada	+905.525.9140 ext.24183	riskmj@mcmaster.ca
Murray Roberts	Scottish Association for Marine Science	+44 1631.55.92.41	m.Roberts@dml.ac.uk

Kathy Scanlon	U.S. Geological Survey	+508.457.2323	kscanlon@usgs.gov
Andy Shepard	NOAA's Undersea Research Program	+910.962.2446	sheparda@uncw.edu
Vik Unnithan	University College Dublin, Eire	+353 1 7162079	vikram.unnithan@ucd.ie
Ann Vanreusel	Ghent University, Belgium	+32.82.64.85.21	Ann.Vanreusel@rug.ac.be
Andy Wheeler	University College Cork, Ireland	+353.21.490.39.51	a.wheeler@ucc.ie
Margaret Wilson	National University of Ireland, Galway	+353.91.52.44.11 ext. 2310	margaret.Wilson@nuigalway.ie